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SHOMURA, R. S. ET AL.

Report of the IPFC Group of Experts on the Indian Ocean

PRESENT STATUS OF FISHERIES AND ASSESSMENT OF POTENTIAL RESOURCES OF THE INDIAN OCEAN AND ADJACENT SEAS

Rome, 23-25 January 1967

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1967

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THE PRESENT STATUS OF FISHERIES AND ASSESSMENT OF POTENTIAL RESOURCES OF THE INDIAN OCEAN AND ADJACENT SEAS

By

R.S. Shomura, D. Menasveta, A. Suda and F. Talbot

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PREPARATION OF THIS REPORT

This is the third version of a report prepared by the Group of Experts on the Indian Ocean established by the Twelfth Session of the Indo-Pacific Fisheries Council (IPFC), Honolulu, Hawaii, U.S.A., October, 1966. The Group of Experts is an advisory body to the Committee on Fisheries or any other body concerned with programming and co-ordination of fishery investigations in the Indian Ocean. Its members are: Mr. R.S. Shomura, Convenor (U.S.A.), Dr. D. Menasveta (Thailand), Dr. A. Suda (Japan), and Dr. F. Talbot (Australia).

The Group held its first meeting in FAO, Rome, in January 1967 to advise the Committee on Fisheries Working Party on the Rational Utilization of the Fishery Resources of the Indian Ocean which considered the first version of this report, issued as working paper COFI:I/1/67/9. It was subsequently revised and reissued in April 1967 under the same symbol as a document of the Second Session of the Committee on Fisheries.

It describes the general oceanographic features of the Indian Ocean and adjacent seas, the pelagic fisheries and the coastal fisheries and suggests areas of potential resource expansion.

The views expressed in this report are those of the authors and not necessarily those of the Food and Agriculture Organization of the United Nations.

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1. INTRODUCTION

Of the three major oceans, the Indian Ocean and its adjacent seas rank last in terms of contribution to world production of marine foodstuffs. In 1964 the production of the oceans and their adjacent areas was 25.4 million metric tons for the Pacific, 18.1 million metric tons for the Atlantic, and only 2.0 million metric tons for the Indian Ocean (FAO, 1967). Although this difference could be explained on the basis that the total area of the Indian Ocean and adjacent seas is considerably less than that of either the Atlantic or Pacific Oceans, a rough adjustment for these areal differences still shows a low yield from the Indian Ocean.

In 1964 the average yield in metric tons per km^2 for the oceans and their adjacent areas was roughly 0.17 for the Atlantic, 0.14 for the Pacific, and 0.03 for the Indian Ocean (Table 1). These results suggest either that the conditions in the Indian Ocean are drastically different from those in the other two oceans and therefore support smaller amounts of fishery resources, or that the Indian Ocean and its adjacent seas are not being fished to their maximum potential. If the latter is true, the Indian Ocean contains vast latent or underutilized resources.

TABLE 1. Comparison of marine catch of the three major oceans and their adjacent seas

Ocean	Area[1/] (10^6 km^2)	Marine catch for 1964[2/] (million metric tons)	Metric tons per km^2
Atlantic	106.463	18.1	0.17
Pacific	179.679	25.4	0.14
Indian	74.917	2.0	0.03

1/ From Sverdrup, Johnson, and Fleming (1946).

2/ From FAO (1967).

One difference between the oceans is the presence of temperate areas in the Atlantic and Pacific Oceans which support large fisheries, and the lack of equivalent temperate areas in the Indian Ocean. The presence of rich fisheries within tropical latitudes off Peru as a result of upwelling indicates, nevertheless, that great yields need not necessarily come from temperate climates. Although conceivable, it is highly unlikely that the low production in the Indian Ocean results from basic shortcomings in the physical and chemical makeup of the Indian Ocean. On the contrary, there is evidence that productivity in some areas of the Indian Ocean equals or exceeds that of the most productive areas of other oceans. Ryther and Menzel (1965), who used the C^{14} method to determine carbon assimilation, obtained rates of productivity of 5.7 and 6.4 g carbon/m^3/day for two stations off the Gulf of Oman. They indicated that these values were "...higher than ever before reported for the ocean." Furthermore, the average rate for 30 stations in the Arabian Seas was 1.8 g carbon/m^3/day, a value considerably higher than the average for oceanic waters.

If productivity is similar in the three oceans, the yield of marine resources in the Indian Ocean would have to be increased fourfold to sixfold to bring it to a level comparable to that of the Atlantic and Pacific. This potential level may be minimal, since there is some evidence that the maximum yields for the Atlantic and Pacific Oceans have not yet been attained.

The pelagic longline fishery is operationally the same in all the oceans, but striking differences are evident when one compares the coastal fisheries of the Indian Ocean with those of the Atlantic and Pacific. First, although there are many individual fisheries in the Indian Ocean, they are all very small. Second, they depend on the use of gear of

relatively low efficiency. Whereas the fisheries in the other oceans use highly mechanized boats (e.g., the large stern trawlers of the Grand Banks fishery in the North Atlantic Ocean), the fisheries of the Indian Ocean generally use small craft with little or no mechanized power. Much of the fishing in the coastal waters of the Indian Ocean and adjacent seas is limited to waters near coastal ports. The range is to a large extent limited by the small size of the craft and the general lack of refrigeration.

As we indicate in the present report, the data on the pelagic fisheries suggest that the quantity of pelagic resources now being harvested by the longline technique may be at the upper limit of rational harvesting--and that there is an immediate need for basic data that will permit accurate estimates of the maximum sustainable yields for each of the commercially important species. On the other hand, there is every indication that the coastal resources are underutilized and that there is potential for considerable development and expansion.

We describe here the general oceanographic features of the Indian Ocean and adjacent seas, the pelagic fisheries, and the coastal fisheries, and suggest areas of potential resource expansion.

In presenting the data, we have separated the marine resources into two broad categories, namely the pelagic and the coastal fisheries. It should be stressed that a clear-cut spatial separation of these two categories is not possible nor desirable. For convenience the principal species included in the pelagic fisheries section are the tunas and billfishes. Although these species occur at various depths in waters a considerable distance from land masses, some species are also commonly caught close to shore and with shore species. Rather than treat these occurrences under the coastal category we consider it essential that our discussions be resource-oriented rather than space-oriented.

2. OCEANOGRAPHY

The dominant features in the circulation of surface waters in the Indian Ocean are the two monsoons. The monsoon periods can be separated into the Northern Hemisphere summer (May-September) and the Northern Hemisphere winter (November-March). In the Southern Hemisphere during May-September, the prevailing winds are from the southeast and are referred to as southeast monsoons. North of the equator, these winds shift direction, owing to the coriolis effect, and are known as the southwest monsoons. During November-March, the winds originate over the Asian continent and blow from a general northeast direction in the Northern Hemisphere, where they are referred to as the northeast monsoon. South of the equator, these winds shift direction, owing to the coriolis effect, and become known as the northwest monsoon.

The most prominent oceanographic feature in the Southern Hemisphere is the major counterclockwise gyre between latitudes 8° S and 40° S (Figs. 1 and 2). The northern limb of this gyre is the South Equatorial Current and the entire system is reported to be fairly well developed throughout the year.

In comparison with the southern sector the circulation of surface waters in the northern part of the Indian Ocean is very complex. During May-September Pacific Ocean water passes into the Indian Ocean through the Timor Sea and Torres Strait between New Guinea and Australia (Fig. 1). This water, along with the northern limb of the counterclockwise gyre of the South Indian Ocean, forms the South Equatorial Current and flows westward towards Africa. At the African coast most of the South Equatorial Current Water moves northward along the east African coast as the East African Coastal or Somali Current. A lesser portion of the South Equatorial Current is deflected by Madagascar southwards to form the Agulhas Current. The surface monsoon currents in the Arabian Sea and the Bay of Bengal generally move clockwise. The easterly flowing countercurrent is present throughout the year; during May-September, the axis is at the equator.

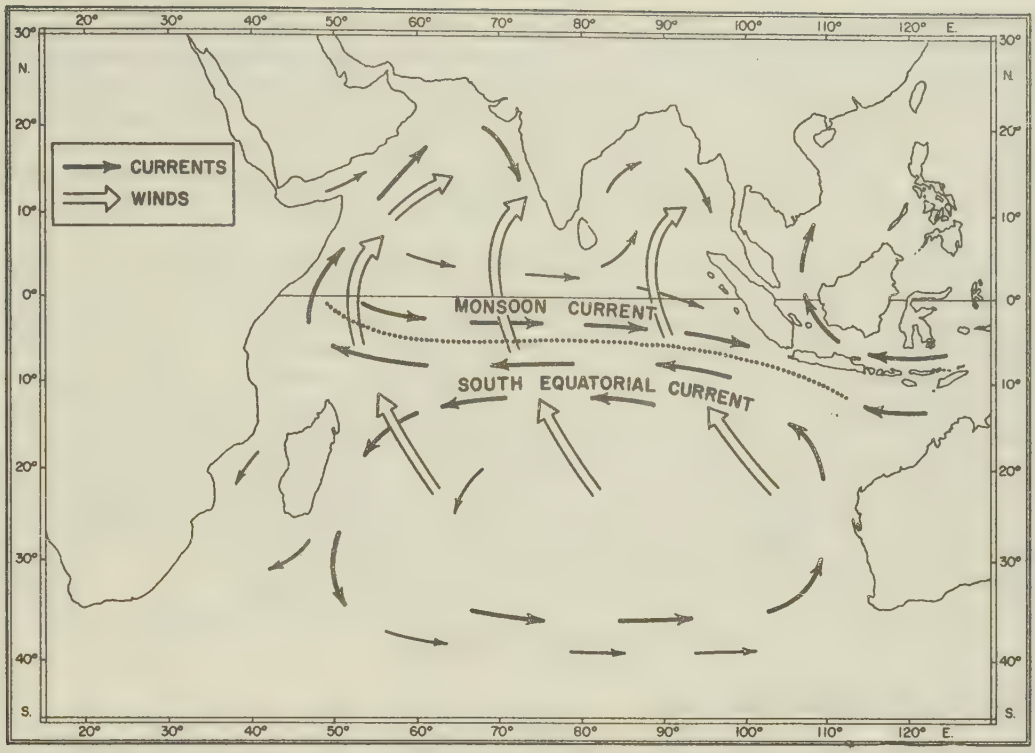

Figure 1. Wind and surface water circulation during the Northern Hemisphere summer period. (From unpublished report by F.S. Osell, U.S. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii.)

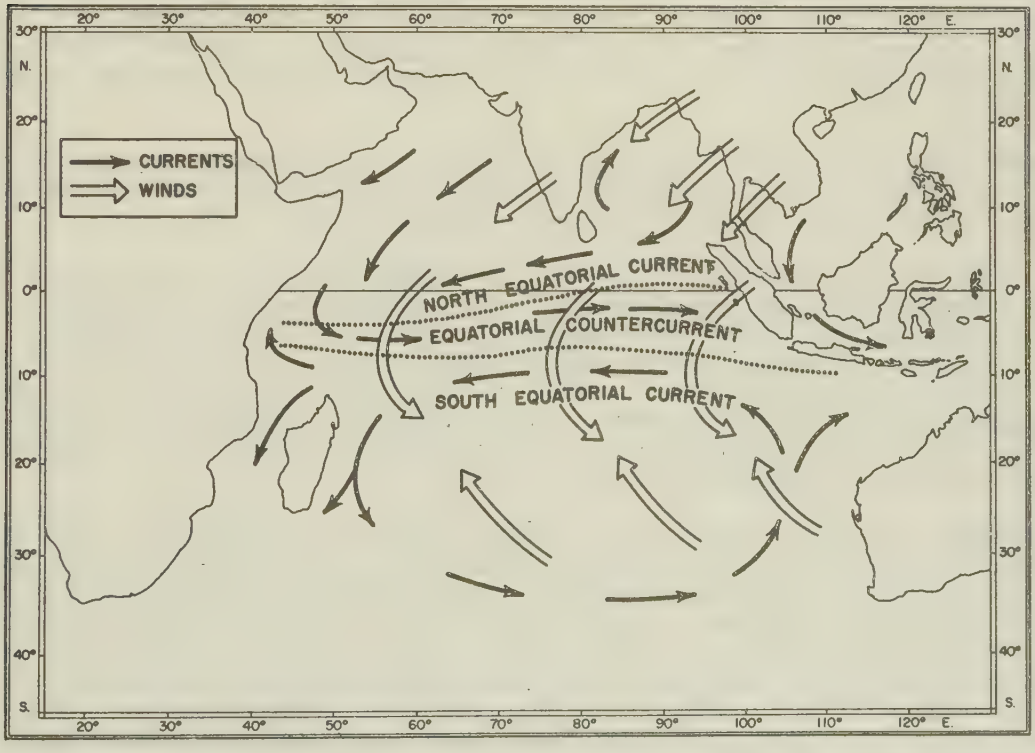

Figure 2. Wind and surface water circulation during the Northern Hemisphere winter period. (From unpublished report by F.S. Osell, U.S. Bureau of Commercial Fisheries Biological Laboratory.)

During the Northern Hemisphere winter, the circulation in the southern part of the Indian Ocean is essentially the same as during the Northern Hemisphere summer (Fig. 2). The core of the Equatorial Countercurrent, however, is displaced to the south and in February lies at approximately latitude 8° S. During this season the easterly flowing current noted in the Northern Hemisphere summer is absent and the surface flow is in general westerly. Thus, the westerly flowing North Equatorial Current exists only during the Northern Hemisphere winter when the prevailing winds are from the northeast.

The foregoing describes in the most general terms the circulation of the surface waters of the Indian Ocean and adjacent seas. Data on the formation of water masses and water types and their areal and temporal distributions are vital in the understanding of marine resources; however, the complexity of the subject precludes a detailed statement in the present summary report. It should be pointed out, however, that a proper appreciation of the influence and effects of the environment on the populations of organisms in the sea requires detailed information on the time and space distributions of water masses, water types and upwellings. Undoubtedly, the tremendous fluctuations in the landings of some coastal fishes, e.g. the oil sardine (Sardinella longiceps) of the west coast of India, are influenced by the year-to-year variations in the physical and chemical environment. Nakamura, Yabuta, and Mimura (1958) suggested a close association between the distribution of pelagic fishes and the major current systems.

3. PELAGIC FISHERIES

3.1 Development of longline fishery

Before the entrance of Japanese commercial longline fishing boats into the eastern Indian Ocean waters in 1952, there was a general lack of knowledge of the distribution and abundance of commercially important pelagic fish species in the Indian Ocean--notably the tunas and billfishes. The pelagic fisheries existing before 1952 were in reality coastal fisheries that harvested species generally considered pelagic in habitat. Included in these so-called pelagic fisheries are the pole-and-line fishery for skipjack tuna (Katsuwonus pelamis) which operates from the island of Minicoy in the Maldive Island group, the handline fishery for yellowfin tuna (Thunnus albacares) in the Gulf of Aden, and the fishery for Euthynnus affinis and longtail tuna (Thunnus tonggol) along the southwest coast of India.

Without including the tunalike scombriform species, e.g. Acanthocybium, it is doubtful that the catch of tunas in the Indian Ocean before 1952 exceeded 10,000 metric tons. Indeed, it is more likely that the landings were around 5,000 metric tons.

The first indication of the existence of a pelagic fishery resource in the Indian Ocean was provided by Japanese exploratory longline fishing cruises conducted before World War II (Kataoka, 1957). In 1930 the exploratory fishing vessel, Shirotaka Maru, fished with longline gear off Andaman and Nicobar Islands in the Bay of Bengal and off the Maldive Islands in the central Indian Ocean. During the early 1930's the Japanese research ship, Haruna Maru, fished off Java and Sumatra. The catches made by these two vessels gave the first indication that commercial quantities of yellowfin tuna and various species of billfishes existed in the Indian Ocean.

In October 1952 the Japanese took advantage of this information and began fishing in the eastern Indian Ocean, primarily for yellowfin tuna. The success of this commercial effort led to an intensification in fishing effort in 1953 and started the development of the Indian Ocean pelagic fishery. Figure 3 shows the areal development of the Japanese longline fishery in the Indian Ocean (Kamimura, 1966). By 1956 the fishing fleet had extended operations as far west as the African coast and by 1960 fishing was carried out from about latitude 15° N to latitude 35° S. Presently longline fishing fleets of other nations--Korea, China (Taiwan), and the U.S.S.R.--are also harvesting the pelagic resources of the Indian Ocean.

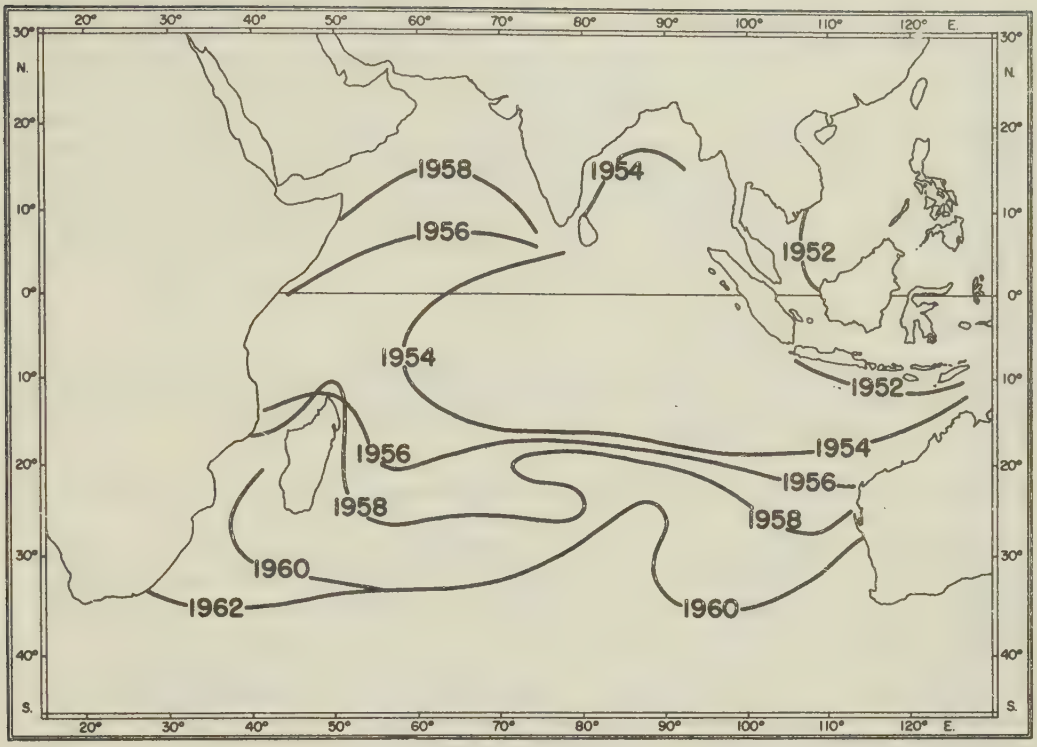

Figure 3. Development of the Japanese longline fishery in the Indian Ocean and adjacent seas. Heavy lines indicate the outer limits of the fishery in different years.

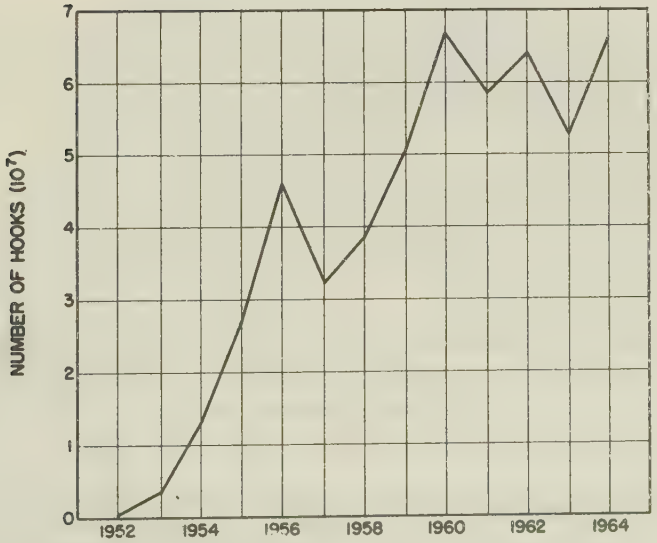

Figure 4.--Estimated Japanese longline fishing effort (hooks) in the Indian Ocean and adjacent seas.

Part of the westward and southward expansion of the fishery was in response to shifts in the principal species sought. In the early years fishing was confined to equatorial waters primarily to catch yellowfin tuna, which then commanded a premium price in the world market. This search for tuna led to the westward expansion of the fishery in equatorial waters. In the middle and late 1950's the decline in yellowfin tuna catch rates and an increased demand for southern bluefin tuna (Thunnus maccoyi) for "sashimi" and fish sausages in Japan led to an increase in effort in the southern bluefin tuna fishing grounds west and northwest of Australia. Finally, the expansion of the fishery in recent years toward the south and southwest was principally to take albacore (Thunnus alalunga) which were encountered in commercial quantities in these sectors.

3.2 Catch and effort data by years

Estimates of the number of hooks fished by Japanese longliners in the Indian Ocean during 1952-64 are shown in Figure 4. Effort increased steadily until 1960 and then leveled at about 60 million hooks per year.

The following should be noted in Figure 5 concerning the annual change in catch:

1. The high catch of yellowfin tuna in 1956 was brought about by the rapid expansion of the fishery into new grounds which contained large virgin stocks. The 1962 high is attributable to the presence of a large year class and the resultant concentration of fishing effort.

2. The increase in southern bluefin tuna catch in 1959 resulted from an expansion of the fishery to the new grounds located south of the previously exploited grounds northwest of Australia.

3. The catch of albacore also shows a gradual increase from 1952. This increase was caused by the southward expansion of the fishery into good concentrations of albacore discovered in the western part of the Indian Ocean.

3.3 Yellowfin tuna

3.3.1 Distribution. Yellowfin tuna are tropical in habitat and the greatest concentrations are in equatorial waters (Fig. 6). This species is taken in varying amounts throughout the southern areas fished, but is virtually absent in the northern waters of the Arabian Sea and the Bay of Bengal.

3.3.2 Availability and abundance. The annual changes in abundance and the number of hooks are shown in Figure 7. The decline in hooking rate indicates the reduction in population by fishing. The average size of yellowfin tuna taken by longline gear has reportedly decreased since the start of the fishery (Mimura, 1958).

3.3.3 Spawning and maturation. A study of gonad development indicates that spawning occurs throughout tropical waters nearly year-round (Figs. 8a and 8b). The distribution of yellowfin tuna larvae is shown in Figure 9. Although the available data are few, the larval distribution tends to coincide with the areas of peak gonad development.

3.3.4 Subpopulations and migration. No evidence of the existence of subpopulations is available. Mimura (1958) suggested that yellowfin tuna migration in the Indian Ocean is not extensive, since high catch rates were attained in each newly exploited area. This condition would not have existed if fishing pressure was being exerted on a single highly mobile population.

3.3.5 Population dynamics and stock assessment. Some estimates of the coefficient of natural and fishing mortalities have been computed for yellowfin tuna in the Indian Ocean (Kawakami and Kitahara, 1964; Hayashi, 1966). The relative abundance of young (3-year-old)

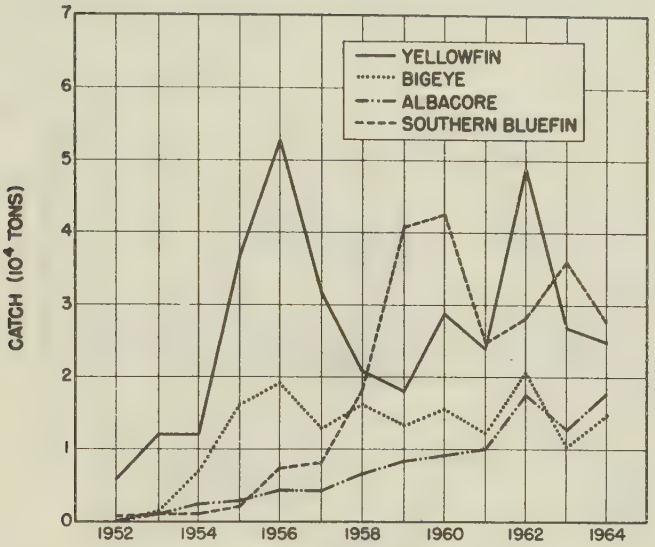

Figure 5. Estimated total tuna catch by the Japanese longline fishery in the Indian Ocean and adjacent seas.

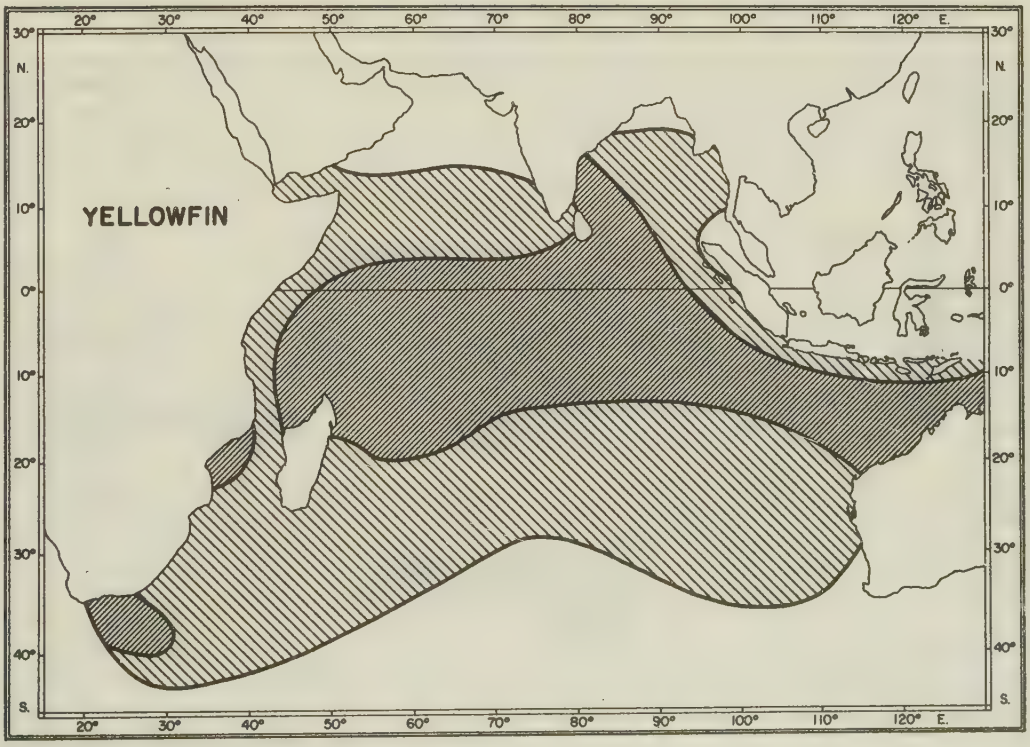

Figure 6. Distribution of yellowfin tuna in the Indian Ocean and adjacent seas. (Darker areas denote greater concentrations.)

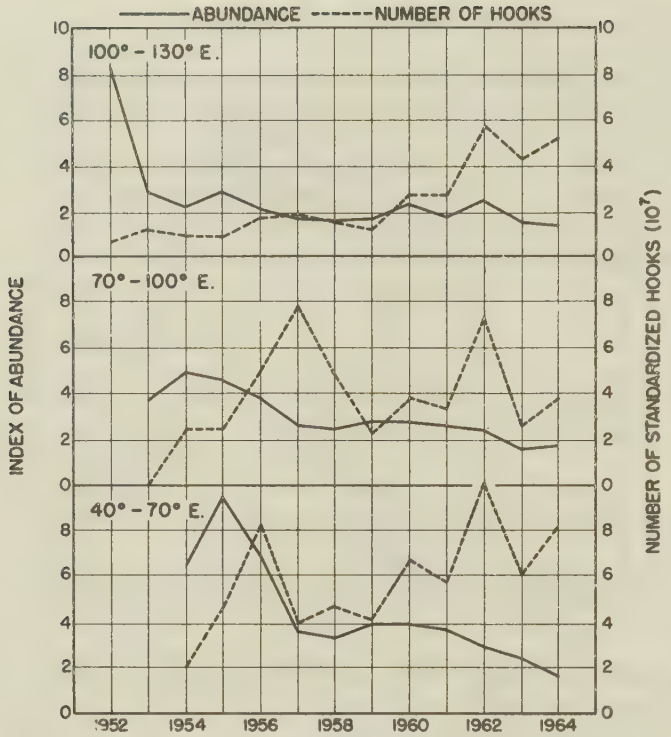

Figure 7. Annual changes in relative abundance of yellowfin tuna and fishing effort, 1952-64. (Index of abundance and standardized hooks reflect adjustments for non-random distribution of species and of fishing effort.)

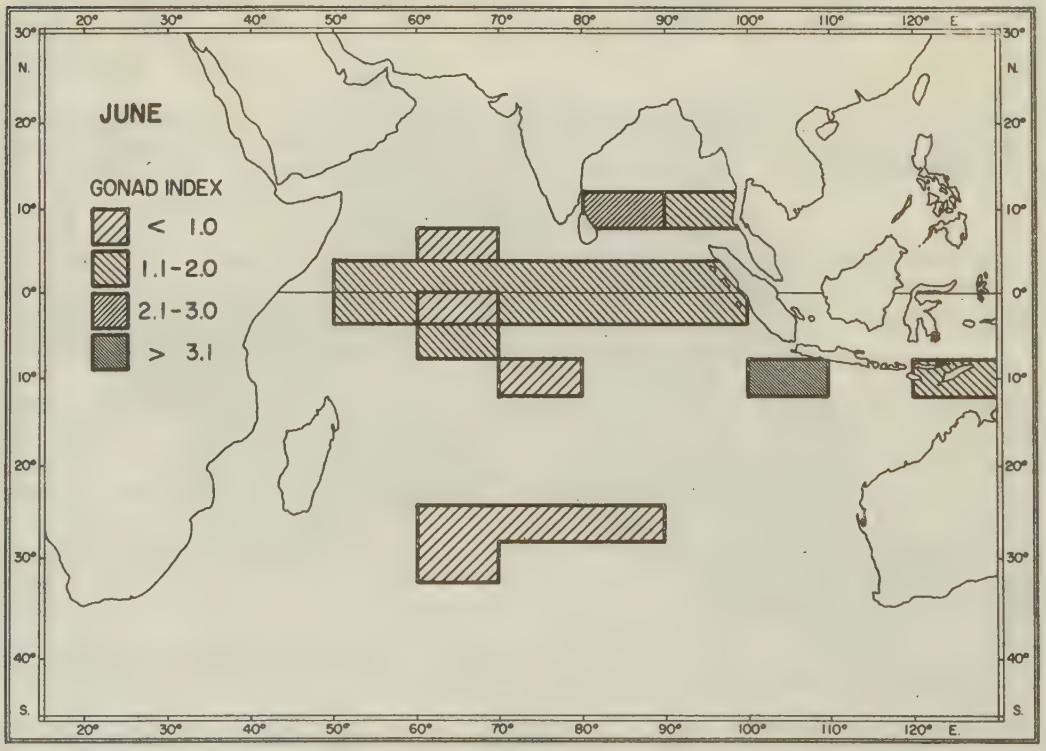

Figure 8a. Maturation of yellowfin tuna in the Indian Ocean and adjacent seas in June.

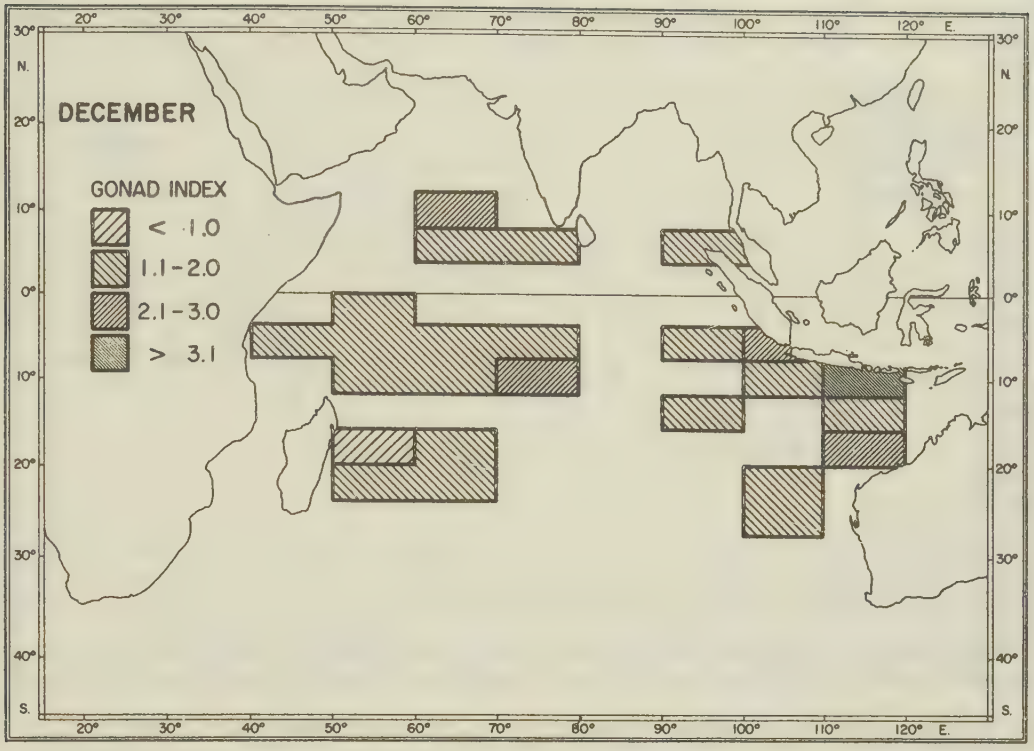

Figure 8b. Maturation of yellowfin tuna in the Indian Ocean and adjacent seas in December. (For key to gonad index, see Figure 8a.)

fish has not shown a noticeable decrease with increasing fishing effort, which suggests that recruitment is being maintained. Hayashi (1966), on the basis of catch and effort data, suggested that the present fishing intensity may be very close to the maximum level for rational utilization of this species in the Indian Ocean.

3.4 Bigeye tuna

3.4.1 Distribution. Bigeye tuna are taken throughout the longline fishing grounds in the Indian Ocean (Fig. 10). In tropical waters the greatest concentrations appear to be between the equator and latitude 10° S in the eastern Indian Ocean and between the equator and latitude 10° N in the western Indian Ocean. At higher latitudes, relatively good bigeye tuna catches have been made in waters off South Africa.

3.4.2 Availability and abundance (Fig. 11). Sakamoto (1966) recently analyzed catch and effort data and concluded that the population of bigeye tuna has decreased in the Indian Ocean since the start of the fishery. The rate of decrease, however, is considered small. The abundance of fish over 5 years old declined dramatically as a result of fishing the accumulated stocks. The abundance of 2-, 3-, and 4-year-olds has leveled off.

3.4.3 Maturation and spawning. Spawning takes place in the same areas as that of the yellowfin tuna. On the basis of gonad studies (Kikawa, 1966), spawning is said to occur throughout the year. Very little is known about the occurrence of larval and juvenile bigeye tuna in the Indian Ocean.

3.4.4 Subpopulations and migration. A suggestion of an east-west migration is indicated by the areal shifts in bigeye tuna concentrations (H. Sakamoto, unpublished data).

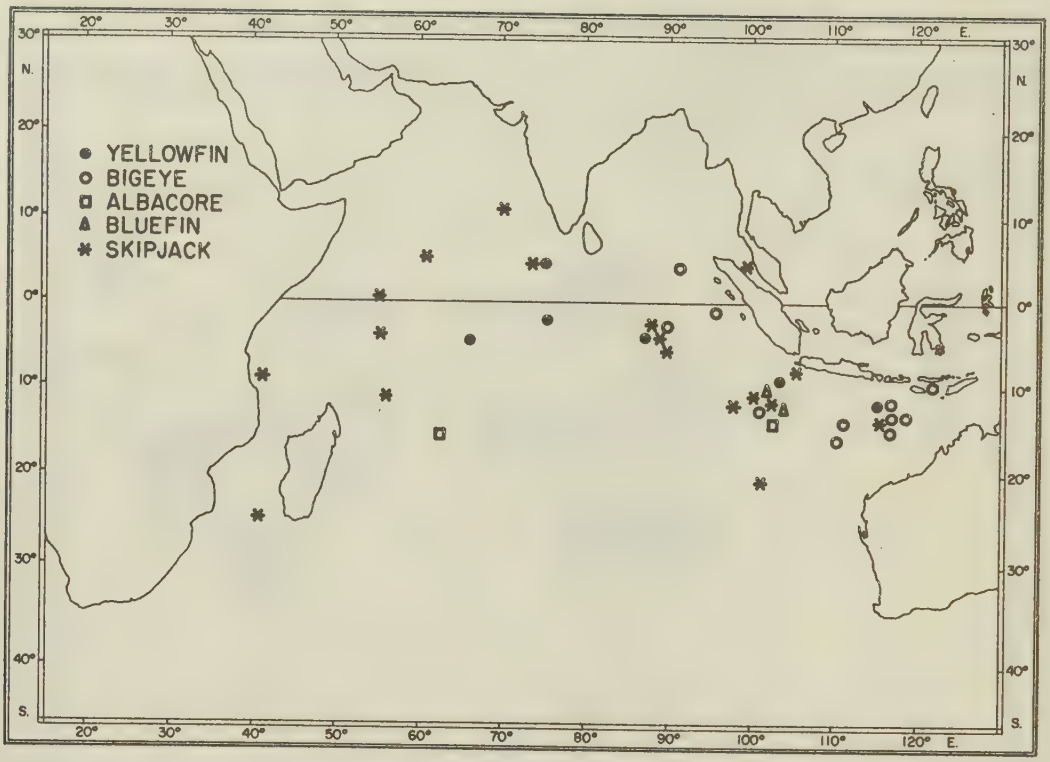

Figure 9. Distribution of tuna larvae in the Indian Ocean and adjacent seas.

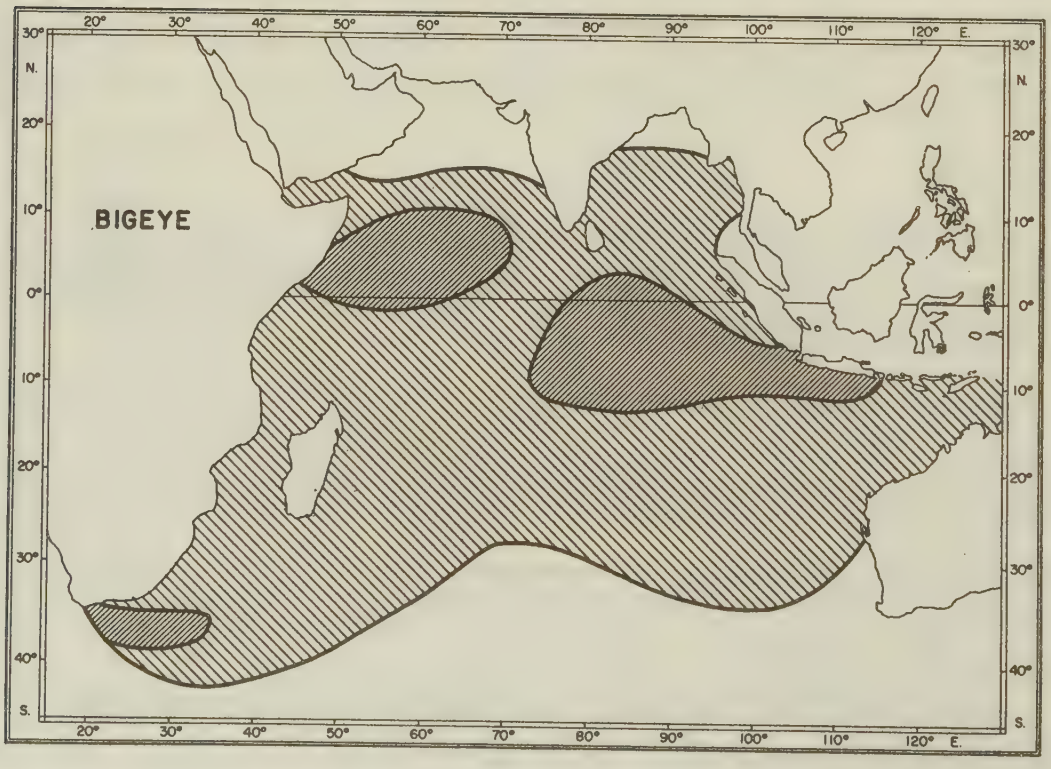

Figure 10. Distribution of bigeye tuna in the Indian Ocean and adjacent seas. (Darker areas denote greater concentrations.)

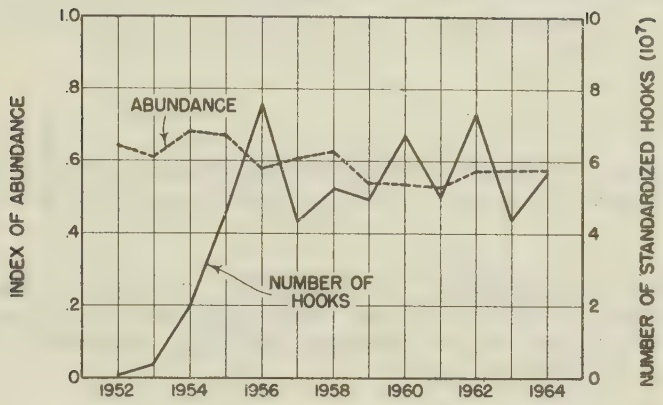

Figure 11. Annual changes in relative abundance of bigeye tuna and fishing effort, 1952-64. (Index of abundance and standardized hooks reflect adjustments for non-random distribution of species and of fishing effort.)

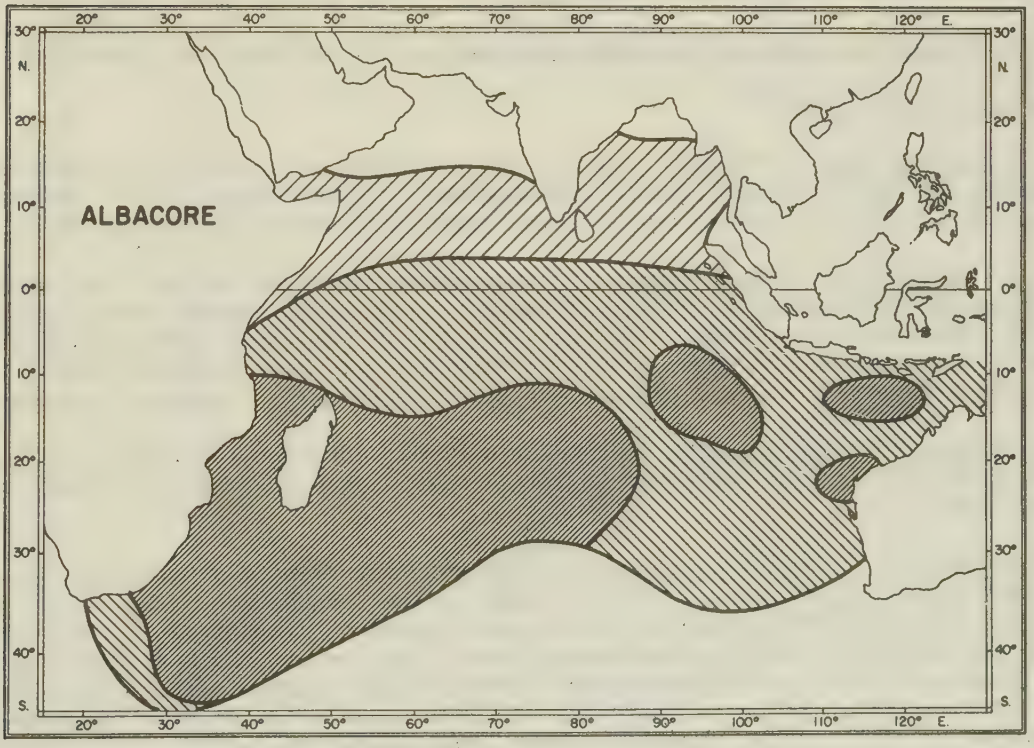

Figure 12. Distribution of albacore in the Indian Ocean and adjacent seas. (Darker areas denote greater concentrations.)

3.4.5 Population dynamics and stock assessment. Suda (1966) computed the coefficient of natural mortality for bigeye tuna to be approximately 0.6. The fishing mortality coefficient fluctuated between 0.3 and 0.6; the higher value was in 1956. Suda (1966) concluded that the maximum sustainable yield of bigeye tuna would be achieved at a fishing mortality coefficient of 0.7.

3.5 Albacore

3.5.1 Distribution. In the Indian Ocean and adjacent seas the albacore is virtually absent north of the equator (Fig. 12). The greatest density is in the southwest sector of the Indian Ocean.

3.5.2 Availability and abundance. A remarkable increase in fishing effort in 1962 resulted from the southern expansion of the fishing grounds into the western Indian Ocean (Fig. 13). The relative abundance of albacore gradually decreased after 1953, and in 1963 was about half that of the earlier years.

3.5.3 Maturation and spawning. Albacore with well-developed ova were caught in an area in the western Indian Ocean roughly bounded by latitudes 10° S and 30° S (Kikawa and Ferraro, in press). Detailed data are not available on albacore spawning in the Indian Ocean. Information on occurrence and distribution of larval and juvenile albacore is also lacking.

3.5.4 Subpopulations and migration. Marr and Sprague (1963), on the basis of albacore blood group frequency data published by Suzuki, Morio, and Mimoto (1959), concluded that the Indian Ocean sample was a mixture of two or more subpopulations. No evidence is available on the existence or extent of intermingling of Indian Ocean albacore with albacore from the Pacific and Atlantic Oceans.

3.5.5 Population dynamics and stock assessment. No information is available.

3.6 Southern bluefin tuna

3.6.1 Distribution. Southern bluefin tuna are taken in abundance northwest, west, and southeast of Australia (Fig. 14). This species is also reported to be present in large numbers off South Africa during the Southern Hemisphere winter (Talbot and Penrith, 1963).

3.6.2 Availability and abundance. A substantial increase in catch of southern bluefin tuna off the Australian coast was brought about by increased effort by the Australian pole-and-line fishery. The average level of abundance (1958-64) of the southern bluefin tuna is now about one-third of the level of the earlier years. The abundance of fish older than 8 years has decreased drastically, especially since 1962.

3.6.3 Maturation and spawning. Spawning has been reported to occur in tropical waters northwest of Australia from September to March, with a peak in November (Mimura and Warashina, 1962).

3.6.4 Subpopulations and migration. C. Shingu (unpublished manuscript) developed a model of the migration of southern bluefin tuna in the Indian Ocean (Fig. 15). On the basis of the model, southern bluefin tuna spawn northwest of Australia. The young move southward and eastward along the Australian coast. Fairly extensive movement of small southern bluefin tuna in south Australian waters has been demonstrated by tag recoveries (Robins, 1963). Return of large, maturing southern bluefin tuna to the spawning grounds is postulated to occur in the offshore waters south of Australia.

3.6.5 Population dynamics and stock assessment. The Australian and Japanese catch of 1.5 million southern bluefin tuna has been estimated to represent about 10 percent of the population of southern bluefin tuna off South Australia (Hynd, Kesteven, and Robins, 1966).

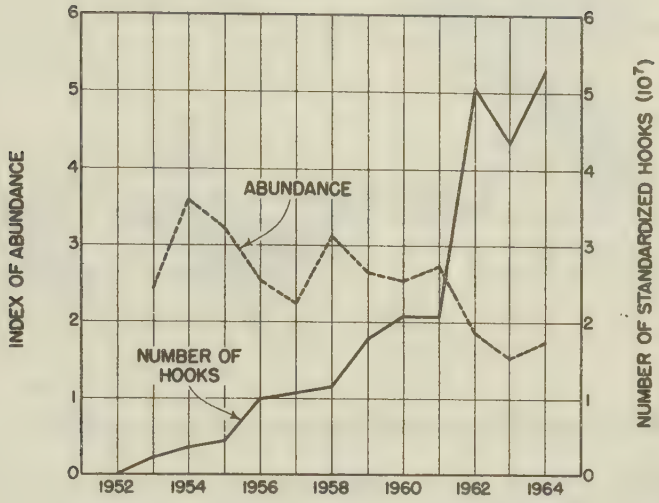

Figure 13. Annual changes in relative abundance of albacore and fishing effort, 1952-64. (Index of abundance and standardized hooks reflect adjustments for non-random distribution of species and of fishing effort.)

Figure 14. Distribution of southern bluefin tuna in the Indian Ocean and adjacent seas. (Stippling denotes recent catches by longline.)

Figure 15. Migratory routes of the southern bluefin tuna off Australia and New Zealand. Stippling denotes catches by longline. (From an unpublished manuscript by C. Shingu, Nankai Regional Fisheries Research Laboratory, Kochi, Japan.)

Figure 16 shows the yield-per-recruit relationship for bluefin tuna computed by Hayashi (1966). The relationship was determined from data from the pole-and-line fishery in coastal waters as well as the longline fishery in offshore areas. The pronounced decrease in abundance of the advanced age group has been directly attributed to the increase in fishing pressure, and indirectly to the reduced recruitment resulting from increased catch in the longline grounds in the Pacific and the pole-and-line fishery off Australia.

3.7 Marlins

3.7.1 Distribution. The distributions of striped marlin (Tetrapturus audax), blue marlin (Makaira nigricans), and black marlin (M. indica) are shown in Figures 17, 18, and 19. Striped marlins are abundant in the Bay of Bengal and along the southern coast of India. The center of abundance of blue marlin appears to be south of the center of abundance of striped marlin. The highest density of black marlin is in the eastern Indian Ocean.

3.7.2 Availability and abundance. Changes in availability and abundance have not been determined for the three species of marlins, although some data are available.

3.7.3 Maturation and spawning. Spawning takes place in the subtropical and tropical waters.

3.7.4 Subpopulations and migration. No information is available.

3.7.5 Population dynamics and stock assessment. No information is available.

3.8 General needs for future studies

3.8.1 Data on catch and effort and size frequency. Accurate estimates of population abundance require the availability of accurate catch and effort data. The Japanese now have a highly developed sampling program to collect longline data. Even under their sampling system, however, it has been necessary to estimate the total oceanwide catch and effort on the basis of only a small fraction of the fishery that has been sampled. As indicated earlier, other countries--China (Taiwan), Korea, and U.S.S.R.--are now fishing in the pelagic waters of the Indian Ocean. Data on catch and effort from these countries are not readily available.

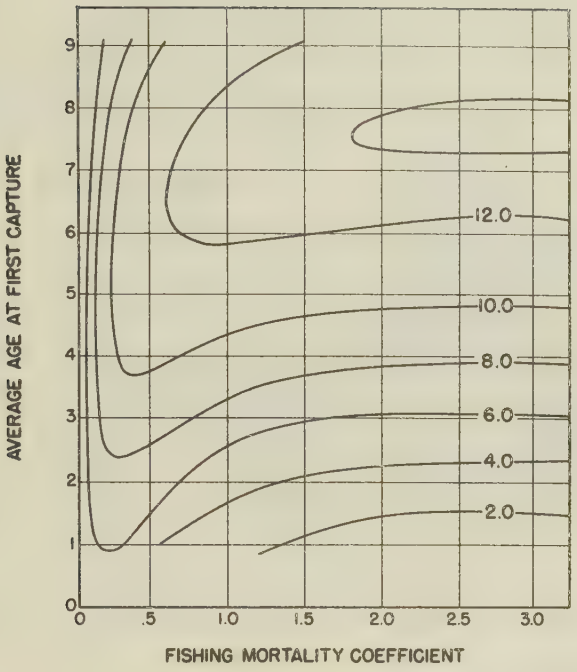

Figure 16. Yield-per-recruit relationship of southern bluefin tuna. (From Hayashi, 1966.)

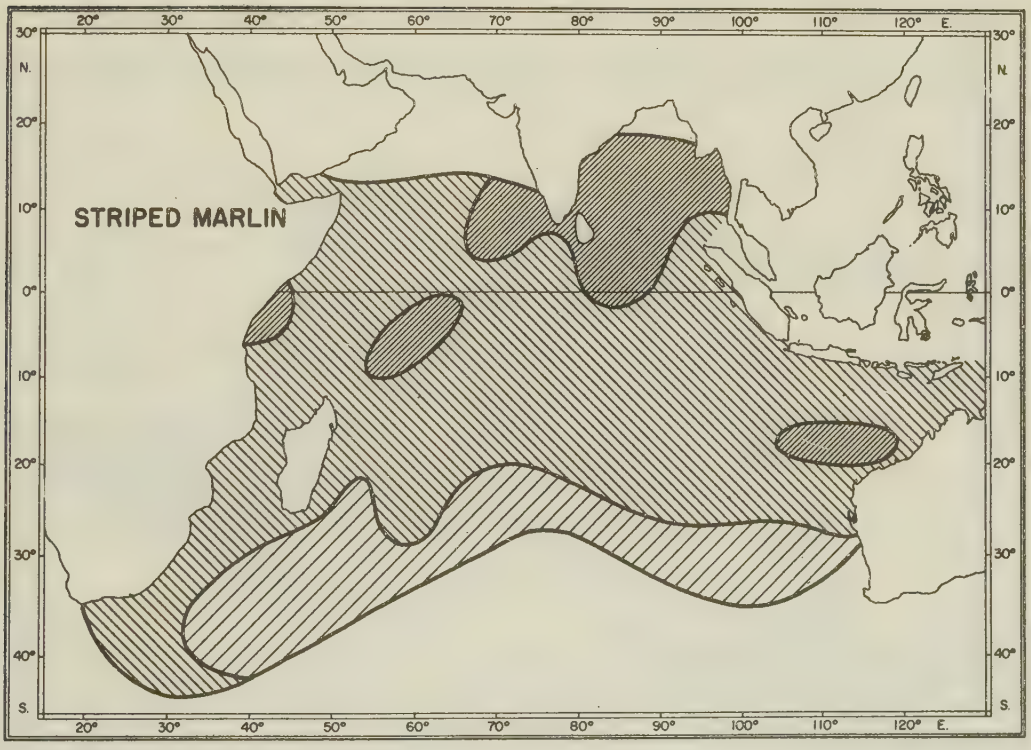

Figure 17. Distribution of striped marlin in the Indian Ocean and adjacent seas. (Darker areas denote greater concentrations.)

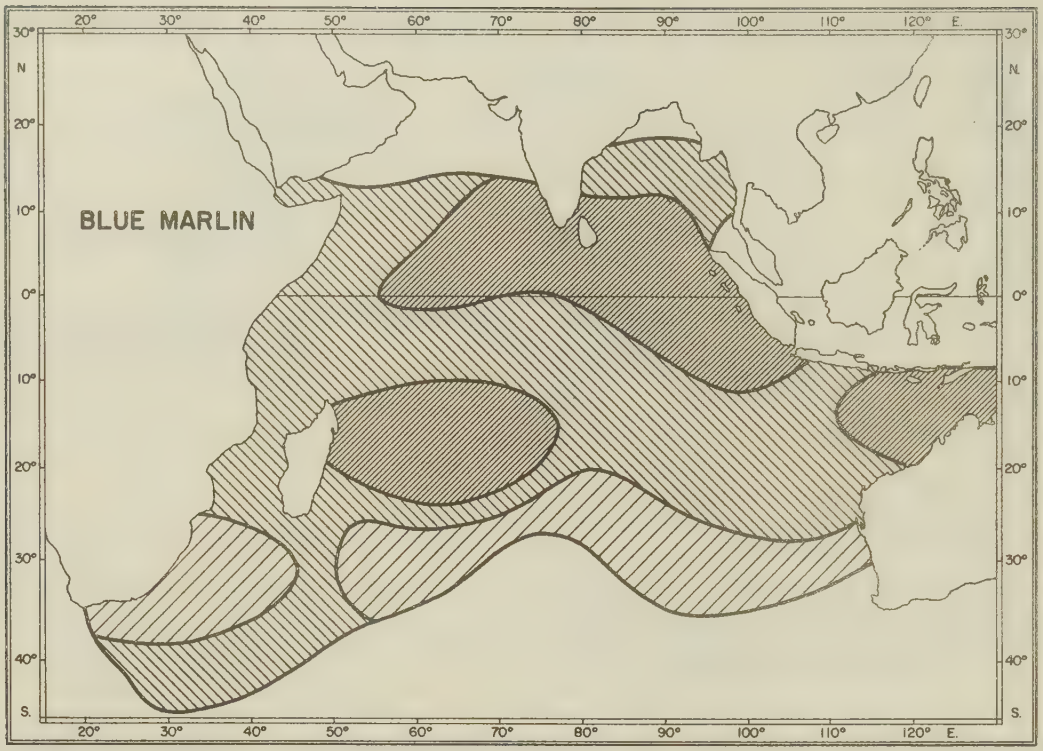

Figure 18. Distribution of blue marlin in the Indian Ocean and adjacent seas. (Darker areas denote greater concentrations.)

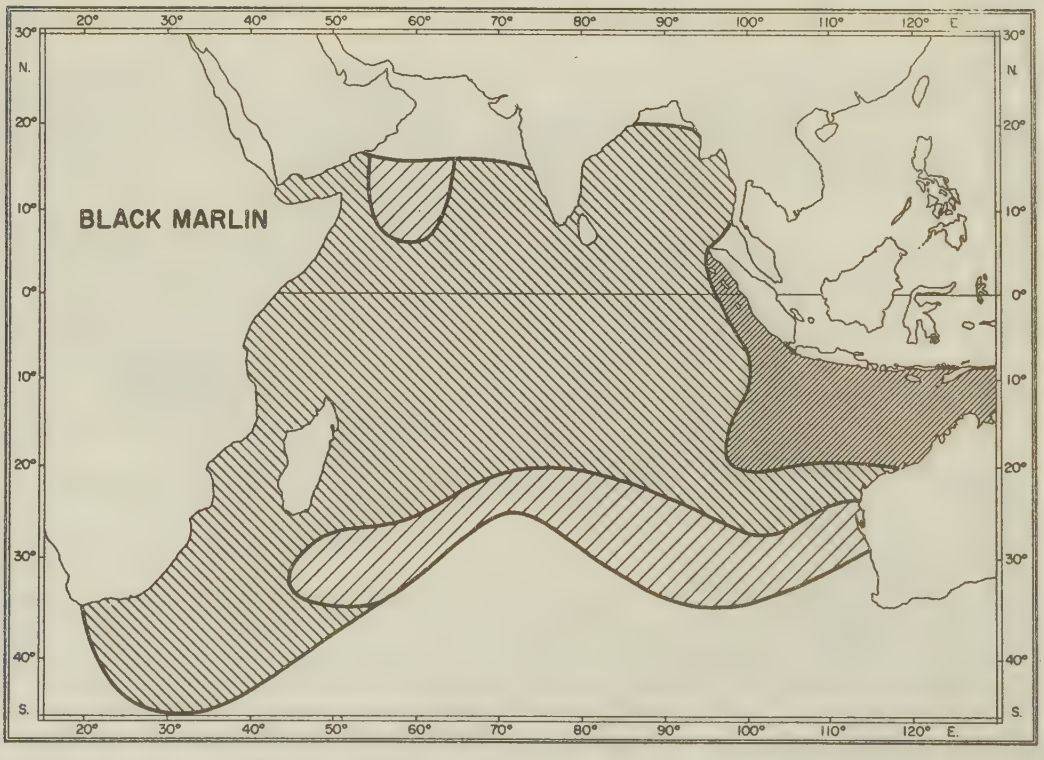

Figure 19. Distribution of black marlin in the Indian Ocean and adjacent seas. (Darker areas denote greater concentrations.)

3.8.2 Subpopulation studies. It is obvious from the discussion of the various species that information on subpopulations is poor or lacking. Because of the importance of subpopulation data for population dynamics studies, it is highly desirable that tagging experiments and morphometric and serological studies be undertaken.

3.9 Latent resources

3.9.1 Skipjack tuna. Although a number of the tuna species in the Indian Ocean are being taken by the longline gear at levels which suggest little or no potential increase, the skipjack tuna gives every indication of being a vast underutilized resource. Presently the principal fisheries for skipjack tuna are the pole-and-line fishery of Minicoy and the small trolling fishery of Ceylon. Complete data on the total skipjack tuna production in the Indian Ocean is lacking; however, even a generous estimate would place the total annual yield at less than 5,000 metric tons. By comparison, the skipjack tuna yield for the Pacific Ocean is about 250,000 metric tons. Even with this sizable landing in the Pacific the resource is considered to be underutilized, especially in the central tropical Pacific. It is highly conceivable that there is also a large resource of skipjack tuna still to be harvested in the Indian Ocean.

3.9.2 Saury. Sauries have been encountered throughout a wide area of the southern Indian Ocean. As with skipjack tuna, the saury may represent a large latent resource.

4. COASTAL FISHERIES

4.1 Introductory note

To facilitate the compilation of information on important coastal fisheries, the coastline of the Indian Ocean has been divided into the following areas (Fig. 20):

1. South Africa (Indian Ocean coast)
2. East African coastal region (Mozambique, Tanzania, and Kenya)
3. Madagascar
4. Western Indian Ocean islands
5. Gulf of Aden and adjacent areas (Somalia, Aden, Southern Arabia)
6. Red Sea and Gulfs of Suez and Aqabar
7. Gulfs of Persia and Oman
8. Coasts of West Pakistan, India, East Pakistan, and Ceylon
9. Coasts of Burma, Thailand, and Malaysia
10. West coast of Indonesia
11. West coast of Australia

The coastal fisheries of most of the countries bordering the Indian Ocean are in general of an undeveloped, subsistence type. Many countries still use nonmotorized boats and traditional types of gear and techniques, and have not experienced the recent advances in gear technology. Fishing is often very short-range and confined to shallow waters close to the coast.

It is perhaps a truism to state that increased production in many parts of Africa and Asia is possible through mechanization of fishing boats and improvement of the efficiency of gear.

Figure 20. Divisions of coastal and island areas in the Indian Ocean and adjacent seas used in the compilation of available fishery information.

Often, however, the availability of the resource and the catching techniques used are not factors that limit increased production. Production is kept low over much of the Indian Ocean coastal area by other factors, such as availability of storage and distribution facilities at landing areas, fluctuations in supplies and prices of ice, control of prices and catches by powerful middlemen and lack of suitable markets. These controlling factors may be eased by government action.

Panikkar (1966) gave further information on Indian Ocean fisheries.

4.2 Brief summaries of the stocks and potential increases in production in different coastal areas

4.2.1 South Africa (Indian Ocean coast)

4.2.1.1 General description. Coastline with a narrow continental shelf at its northern end widening to the Agulhas Bank (up to 100 miles wide) at the southernmost tip of Africa. The southernmost area is subtropical and the northern tropical. Localized areas of moderately high plankton standing crop, but no major upwelling.

4.2.1.2 Fishing techniques. Trawling with vessels 70 feet long or less, shore seining, handlining from motorized boats, trolling.

4.2.1.3 Species exploited. Flatfish, sciaenids, mugilids, sparids, redfish, seerfish (Scomberomorus commerson), sharks, rock lobster (Palinurus gilchristi), penaeid prawns (northern coast).

4.2.1.4 Present total production. 3.0 thousand metric tons (Indian Ocean coast).

4.2.1.5 Knowledge of stocks. Species identification good; some information on stock size and migrations of pilchard, and on stock size of flatfish.

4.2.1.6 Possible production increase. No precise information. Some stocks, such as the flatfishes of the Agulhas Bank, are probably not capable of increased production. Others, particularly pilchard (Sardinops), and rocky-bottom fishes of the shelf, may be further developed. Increase not likely to be manyfold.

4.2.1.7 Programs for exploration, research, and development. Research investigation into seasonal pilchard run is under way.

4.2.2 East African coastal region (Mozambique, Tanzania and Kenya)

4.2.2.1 General description. Tropical coastline with narrow continental shelf, and without enriched upwelling areas. Typically fringed with mangrove or coral reefs.

4.2.2.2 Fishing techniques. Mostly indigenous fisheries poorly or moderately developed; gear includes handlines, permanent set traps, movable traps, beach seines, set nets, trolling rigs. Some bottom trawling (Mozambique). Some ring netting with lights. Most fishing is without motorized boats, although use of motors is increasing.

4.2.2.3 Species exploited. Sardinella, mixed bottom and coral reef fishes, seerfishes (Scomberomorus commerson, S. lineolatus), sharks, rock lobsters (Palinurus gilchristi off southern Mozambique and Panulirus spp. in other East African coastal areas), prawns and shrimps (Penaeus spp., Metapenaeus spp.).

4.2.2.4 Present total production (thousands metric tons). Mozambique, 5.8; Tanzania, 19.2; Kenya, 5.6; total 30.6. Statistics except for Tanzania are not detailed, but bottom fishes probably constitute well over half of this amount, and Sardinella, sharks and rays, and seerfishes most of the remainder.

4.2.2.5 Knowledge of stocks. Species identification fair. No information on stock sizes.

4.2.2.6 Possible production increase. Fishery clearly capable of increase. Sardinella and other small coastal pelagic fishes little exploited and need attention. Some development of prawn industry possible. In general a twofold, perhaps threefold, increase may be feasible.

4.2.2.7 Programs for exploration, research, and development. Commercial fisheries for shrimp in the Beira area of Mozambique, and for rock lobster (Palinurus gilchristi) are being developed.

4.2.3 Madagascar

4.2.3.1 General description. Extensive coastline, with an extremely narrow shelf on its eastern side, and a wider, although not extensive, shelf area on the western coast. Bathed by South Equatorial Current Water, with little enriching except in a small area of upwelling off the southwestern corner.

4.2.3.2 Fishing techniques. In general a subsistence-level fishery with handlines, set nets, and traps. Trolling for seerfishes (Scomberomorus commerson), trapping for rock lobster (Panulirus spp.), and trawling for prawns are moderately developed.

4.2.3.3 Species exploited. General bottom fishes, seerfishes, rock lobster (Panulirus spp.), prawns (Penaeus spp., Metapenaeus spp.).

4.2.3.4 Present total production. Total production estimated at 5.8 thousand metric tons, with no separation into groups.

4.2.3.5 Knowledge of stocks. Classification of species not well known. No details of stock assessment known. For hydrographic reasons the area would not seem to hold promise of rich fish stocks although the extensive mangrove areas of the Mozambique Channel coast indicate sizable prawn and crab stocks.

4.2.3.6 Possible production increase. No precise information. The sparse population and small number of fishermen would suggest that a manyfold, probably fivefold or more, increase over the 5.8 thousand metric tons is possible. Possibilities of exploitation of Sardinella and associated species on the northwest coast are good.

4.2.3.7 Programs for exploration, research, and development. Research and fishery development are under way on the prawn fishery of the northwest coast. Exploration of the possibilities of a Sardinella fishery on the northwest coast is necessary. Improvement of gear and techniques and use of motorized boats necessary.

4.2.4 Western Indian Ocean islands (Comoro, Mauritius, Reunion, Seychelles, Chagos,...)

4.2.4.1 General description. Scattered tropical islands and banks of both volcanic and coral reef type, stretching over the central and western Indian Ocean. Many are small islands on extensive banks. Fish stocks are those typical of coral reef communities.

4.2.4.2 Fishing techniques. Gear includes handlines, trolling rigs, traps. Motorized boats sometimes used for long-distance fisheries.

4.2.4.3 Species exploited. General coral community bottom fishes, sharks, seerfishes, trevallies.

4.2.4.3 Present total production (thousands of metric tons). Comoro, 1.3; Mauritius, 1.3; Reunion, 2.2; Seychelles, 1.5; total 6.3.

4.2.4.4 Knowledge of stocks. Species identification fair. No stock assessments have been made. Catches off Mauritius are dropping; this area seems badly overfished.

4.2.4.5 Possible production increase. On the basis of exploratory fishing Wheeler (1953) estimated a potential annual demersal fish catch of 2.8 million metric tons for this area. This estimate is greater than the whole Indian Ocean catch reported for 1964. Even if this estimate is much exaggerated, it is probable that this area, which now produces less than 10 thousand metric tons, is badly under-exploited and could be expanded to at least 10 times its current production.

4.2.4.6 Programs for exploration, research, and development. Development under way of a firm based on Mauritius, equipped with freezers, to fish banks. The area needs further survey to confirm Wheeler's potential yield figures.

4.2.5 Gulf of Aden and adjacent areas (Somalia, Aden, South Arabia)

4.2.5.1 General description. This area comprises the tropical East African coastline north of the equator, the Gulf of Aden, and the South Arabian coastline--areas where major upwelling occurs when the southwest monsoon prevails. This upwelling results in primary productivity as high as that in the rich waters off Peru.

4.2.5.2 Fishing techniques. Gear included trolling rigs, handlines, shark nets, ring nets, longlines, and trawls by outside countries, beach seines.

4.2.5.3 Species exploited. Sharks and skates, tuna, seerfish (Scomberomorus commerson), Sardinella and associated species, percomorph bottom fishes.

TABLE 2. Landings of commercially important fish and crustaceans in India, 1959-64[1/]

Species or group	Landings in metric tons (average for 1959-64)
Oil sardine (*Sardinella longiceps*)	145,736
Bombay duck (*Harpodon nehereus*)	91,911
Prawns and shrimps	68,267
Indian mackerel (*Rastrelliger* spp.)	67,714
Elasmobranchs	37,549
Other sardines (*Sardinella* spp.)	33,217
Sciaenids	27,014
White baits (*Anchoviella* spp.)	24,694
Carangids (*Decapterus* spp., *Megalaspis*, *Selaroides*, and *Caranx* spp.)	22,794
Ribbonfishes (*Trichiurus* spp.)	20,780
Silverbellies (*Leiognathus* spp.)	20,285
Pomfrets (*Pampus* spp. and *Parastromateus niger*)	20,170
Catfishes (*Tachysurus* spp. and *Osteogeniosus* spp.)	19,118
Big-jawed jumper (*Lactarius lactarius*)	10,917
Seerfishes (*Scomberomorus* spp.)	9,650
Eels (*Muraenesox* spp.)	7,462
Wolf herrings (*Chirocentrus* spp.)	7,235
Tunnies	4,666
Threadfins (*Polydactylus*, *Polynemus*, *Eleutheronema* spp.)	4,387
Grey mullets (*Mugil* spp., *Liza* spp., *Valamugil*, and *Rhinomugil* spp.)	1,215

1/ Data from Jones (in press).

4.2.5.4 Present total production (thousands of metric tons). South Arabia, 52.0; Somalia, 4.5; total 56.5

4.2.5.5 Knowledge of stocks. Species identification poor. No data for stock assessment.

4.2.5.6 Possible production increase. Productivity values suggest a fishery potential richer for this area than for any other in the western Indian Ocean. M.B. Schaefer (personal communication) estimated a production as high as 10 million metric tons, or 200 times the present catch. It is likely that this would be mainly of Sardinella and other small inshore pelagic species. Without further estimates of primary production along the whole coastline and over the annual cycle, and some sampling of the fish population, such figures must be treated with caution. Even if the estimates are optimistic, however, this area has enormous potential.

4.2.5.7 Programs for exploration, research, and development. Special fund project (UK 38). Survey of the fishery resources of the Gulf of Aden.

4.2.6 Red Sea and Gulfs of Suez and Aqabar (Ethiopia, Sudan, United Arab Republic, Israel, Jordan, Saudi Arabia, Yemen)

4.2.6.1 General description. The coastal waters of this narrow sea are bounded by coral reefs. Wide shelfs exist only at the southern end of the Red Sea, on the Yemen and Ethiopian coasts. Hydrographically the Red Sea may be considered moderately productive.

4.2.6.2 Fishing techniques. Over most of the area traditional gear is in use, including traps and pots, handlines, trolling lines, set nets and seines, and nonmotorized boats. Although some bordering countries (e.g., Israel) have larger vessels, these are generally used outside the Red Sea.

4.2.6.3 Species exploited. Demersal coral reef species, sharks and rays, herrings, sardines and anchovies, seerfishes and trevallies.

4.2.6.4 Present total production (thousands of metric tons). U.A.R., 9.8; Sudan, 1.6; Ethiopia, 8.9; Saudi Arabia, 6.0; Jordan, 0.2; Israel, 1.3; Yemen, 2.5; total 30.3.

4.2.6.5 Knowledge of stocks. Classification of species moderately well known. No stock assessment figures available.

4.2.6.6 Possible production increase. Unknown. Various fishery experts consider further exploitation possible for sardines, bottom fish, and other coastal fishes (El Saby and Farina, 1954; Ferrer, 1958; Oswald, 1958).

4.2.6.7 Programs of exploration, research, and development. Request submitted by Jordan for special fund project on fisheries. Improvement of techniques and gear, and motorizing of local boats necessary.

4.2.7 Gulfs of Persia and Oman (Oman, Trucial Oman, Saudi Arabia, Kuwait, Iraq, Iran, Qatar)

4.2.7.1 General description. The Persian Gulf is extremely shallow--under 15 fathoms in average depth and 30 fathoms in maximum depth. Muddy areas near the deltas and sand and coral reefs along much of the shore. The junction between the Persian and Oman Gulfs is shallow, but the Gulf of Oman is 1,500 fathoms deep for half its length. The Gulf of Oman has given extraordinarily rich productivity measures (Ryther and Menzel, 1965).

4.2.7.2 Fishing techniques. The local fisheries are of a subsistence type, without motorized boats; shore seines, gill nets, traps, set traps, handlines and trolling lines are used. Some prawn trawling.

4.2.7.3 Species exploited. Sardines, hilsa, Stromateus spp., general coral reef fishes, small tuna and other pelagic scombroids, and trevallies, prawns.

4.2.7.4 Present total production (thousands of metric tons). Oman, 100.0; Trucial Oman, 12.0; Sauda Arabia, 15.0; Kuwait, 6.8; Iraq, 0.5; Iran, 8.0; Qatar, 0.6; total 142.9.

4.2.7.5 Knowledge of stocks. Classification of species poorly known. No stock assessments made.

4.2.7.6 Possible production increase. Not known. Prawns and Sardinella-type fishes may be under-exploited.

4.2.7.7 Programs for exploration, research, and development. Prawn trawl fishery being developed. Potential fishery for Sardinella-type fishes should be investigated.

4.2.8 Coasts of West Pakistan, India, East Pakistan, and Ceylon

4.2.8.1 General description. The coastal areas of India, Pakistan, and Ceylon are characterized by a long coastline with a prominent shelf along the west coast of Pakistan and the west coast of India. The east coast of India is characterized by a narrow shelf. In the Bay of Bengal the shelf widens to about 120 miles.

The Bay of Bengal receives fresh water from many large rivers; since seasonal precipitation is heavy, the bay has a lower average salinity than the Arabian Sea.

Movement of current along the east and west coasts of India is influenced by the northeast and the southwest monsoons.

The plankton standing crop is higher on the west coast of India than on the east coast. The area is entirely within the tropical zone.

4.2.8.2 Fishing techniques. Fisheries in these areas are more or less on a subsistence level. The fishing gear employed by local fishermen includes bamboo stake traps of various sizes, purse seines, beach seines, gill nets, set bag nets, stake nets, cast nets, and trawl nets.

4.2.8.3 Species exploited. Jones (in press) compiled information on landings fishing gear, and the available biology of the 20 most important species and groups of species of commercial marine fishes (Table 2). His information is based principally on the data from India. Among the 20 species or groups of species listed, three species and three groups of species have landings which are greater than 30.0 thousand metric tons. They are the oil sardine (Sardinella longiceps), the Indian mackerel (Rastrelliger spp.), the Bombay duck (Harpodon nehereus), prawns and shrimps, elasmobranchs, and sardines other than the oil sardine.

4.2.8.4 Present total production. See Table 2 for the average (1959-64) production of various species. Catches in Pakistan and Ceylon combined constitute about one-fourth of the Indian catch.

4.2.8.5 Knowledge of the stocks. Species identification fair. No information is available on the characteristics of the stocks of commercial importance.

4.2.8.6 Possible production increase. No specific information. According to Tiews (in press) trawl fisheries can be expanded in India, Pakistan, and Ceylon. His calculations indicate that it may be possible to harvest about one million metric tons of fish in the available trawling grounds. He estimated the area of these grounds to be about 85,000 square nautical miles.

4.2.8.7 Programs for exploitation, research, and development. Though extensive studies have been made by Indian scientists on the biology (fecundity, stage of maturity, food habits, descriptions of eggs and larvae, ...), only limited studies have been made to determine the causes of the fluctuations in the stocks of these species and population dynamics of the various species.

4.2.9 Coasts of Burma, Thailand, and Malaysia

4.2.9.1 General description. The Indian Ocean coastal areas of Burma, Thailand, and Malaysia are characterized by a long shoreline with many areas of mangrove swamps. These areas are suitable for culture of mussels, prawns, mullets, and other inshore species. The continental shelf, along the coasts of these countries, is 40 to 100 miles wide.

4.2.9.2 Fishing techniques. The fishing gear employed by the Thai and Malaysian fishermen is relatively similar in construction. Fishing is with purse seines of various sizes, traps, and gill nets for the neritic-pelagic species and set bag nets, beach seines, and trawl nets for the semipelagic and bottom species.

4.2.9.3 Species exploited. The data on the unit fisheries of Malaysia (provided by Mr. Soong Min Kong, Director for Fisheries of Malaysia) and Thailand (Tongyai, in press) indicate that the species of fish and crustaceans of economic importance consist of Indian mackerel (Rastrelliger spp.), Decapterus spp., and Stolephorus spp., and wolf herrings for the shelf-pelagic stocks; prawns (Penaeus and Metapenaeus spp.), Lutianus spp., Nemipteridae, and Tachysuridae for the demersal stocks.

4.2.9.4 Present production. Table 3 shows the landings of commercially important species of the west coast of Malaysia for 1965, in decreasing order of importance in terms of economic value.

Table 4 gives the total landings of certain groups of fish on the Indian Ocean side of Thailand.

No production statistics of coastal fisheries of Burma are available.

4.2.9.5 Knowledge of the stocks. Species identification poor. No information on the magnitude of stock sizes in this area. Migrations of the Indian mackerel along the west coast of Malaysia, Thailand, and the coastal waters of Burma are not known.

4.2.9.6 Possible production increase. The production of demersal fishery resources can be increased substantially through the expansion of the trawl fisheries operating on the continental shelf of Malaysia, Thailand, and Burma.

According to Tiews (1966) the trawl fishery on the continental shelf of Burma is capable of producing about 370,000 tons. For Malaysia, Tiews (in press) estimated a production of 600,000 tons.

Improved methods of fishing such as the use of purse seines in combination with light luring techniques, which have been successfully used in the Philippines' basnig fishery, may increase the production of round scad (Decapterus spp.) and Stolephorus spp.

Thailand uses her pelagic and demersal fishery resources in the Gulf of Thailand extensively; however, the resources along the western seaboard of Thailand have not yet been fully exploited. It is expected, however, that the resources in this area will be extensively used by Thailand in the future. During the past two years, the amount of gear fished in this area has increased substantially.

4.2.9.7 Programs of exploration, research, and development. The Department of Fisheries of Malaysia has initiated a program of research on the stocks of Indian mackerels in the area around Penang Island. The biology of the two mackerel species is known fairly

TABLE 3. Estimated landings of commercially important species along the west coast of Malaysia in 1965[1/]

Species or group	Estimated annual yield (metric tons)	Value in local currency (Malaysian dollars)
Prawns (*Penaeus* and *Metapenaeus* and *Macrobrachium* spp.)	8,454	7,218,641
Rastrelliger spp.	8,194	6,365,680
Scomberomorus spp.	2,791	5,950,512
Chirocentrus dorab	2,890	5,588,622
Decapterus spp.	5,055	4,276,859
Mollusc (*Anadara granosa*)	19,381	3,203,730
Lutianus spp.	2,639	3,053,540
Stolephorus spp.	9,172	2,426,048
Clupea spp.	2,625	2,039,988
Mud crab (*Scylla serrata*)	1,117	1,294,020
Nemipteridae	1,629	1,265,146
Tachysuridae	1,207	937,838
Serranidae	502	913,660
Shrimp (Sergestidae)	3,975	788,580
Carangidae	598	693,840

1/ Statistics obtained from Mr. Soong Min Kong, Director of Fisheries, Ministry of Agriculture and Cooperatives of Malaysia (Ref. (34) in Mal. Fish. 1108).

TABLE 4. Estimated landings of commercially important species along the western seaboard of peninsular Thailand 1964-65[1/]

Species or group	Estimated landings in metric tons	
	1964	1965
Rastrelliger spp.	6,331	4,439
Sharks and rays	308	8,685
Miscellaneous fish	13,821	9,162
Shrimps	1,124[2/]	740
Cricket lobsters	--	151
Crabs	150	168
Mollusc	233	229
Sea cucumber	2	--
Loligo spp.	--	321
Seaweed	--	16

[1/] Statistics obtained from the Statistical Section, Department of Fisheries, Bangkok, Thailand.

[2/] Including lobsters.

well. In addition, Malaysia has a trawling survey under way to assess the density of the demersal fishery resources off Penang and Kedah and in Malacca Strait. Also studies on the feasibility of coastal culture of mud crabs and freshwater prawns (Macrobrachium spp.) have been started.

Although Thailand has an extensive program to study the stocks of Rastrelliger in the Gulf of Thailand, a similar program has not yet been started for the same species in the Indian Ocean. Statistics on the size, maturity stages, and production of the species, however, are presently being compiled. A survey of the density of the stocks of demersal fishes was undertaken in 1964.

4.2.10 West coast of Indonesia. No information is available on the commercially important fisheries of Indonesia. It is expected, however, that the composition of the fishery resources is similar to that in North Australia, Malaysia, Thailand, and Burma. Upwellings are found south of the Sunda Isles.

4.2.10.1 Total production.

85	thousand	metric	tons	in	1958
105	"	"	"	"	1961
110	"	"	"	"	1962
115	"	"	"	"	1963

(Statistics from FAO, 1967.)

4.2.11 West coast of Australia

4.2.11.1 General description. Australia has a long coastline facing the Indian Ocean. The continental shelf is narrow--less than 40 miles--in the southwestern part of the continent. Progressing northward, the shelf becomes wider. In the northwest area of the continent, the prominent shelf exceeds 200 miles in width.

4.2.11.2 Fishing techniques. A list of various fisheries of Australia has been prepared by Kesteven and Williams (1965). Eight commercial fisheries are located along the western coast of Australia (G.L. Kesteven, personal communication). These fisheries and the gear used are:

1. Mandurah estuarine and river prawn fisheries - hand scoop nets
2. Western Australian estuarine and river fisheries - set and haul nets
3. Western Australian salmon (Arripis trutta) fishery - beach nets
4. Shark Bay snapper trap fishery - steel-framed, wire-mesh covered traps
5. Western crayfish fishery - crayfish pots
6. Western Australia deep-sea fishery - mesh nets (set) and longline
7. Western Australian deep-sea handline fishery - handline gear
8. West coast prawn fishery - otter trawl nets

4.2.11.3 Species exploited.

Onshore - Mullets (Mugil spp., and Aldrichetta forsteri), whitings (Sillago spp., and Sillaginodes punctatus)

Demersal - Crayfish (Panulirus cygnus and Jasus lalandei), prawns, (Penaeus spp. and Metapenaeus spp.), sharks and rays, flounders

Shelf-pelagic - Scomberomorus spp.

4.2.11.4 Present total production. Table 5 lists the landings of Western Australia and the total Australian landings of five groups of species of commercial importance. It is clear from this table that the most important fishery on the west coast of Australia is the crayfish industry.

4.2.11.5 Knowledge of the stocks. Species identification good for the southern species, poor for the northern species. Australia has carried out biological and population studies on the following species, with the aim of regulating fisheries to obtain optimum sustained harvests:

Australian salmon (Arripis trutta)
Western crayfish (Panulirus cygnus)
Southern crayfish (Jasus lalandei)
King George whiting (Sillaginodes punctatus)
Scallop (Pecten meridionalis)
Prawns (Penaeus latisculcatus, P. esculentus, P. merguiensis)

4.2.11.6 Possible production increase. Northern coasts of Western Australia are virtually unexplored. A sizable stock of shrimps and prawns may exist in this area.

TABLE 5. Australian marine production, 1964-65[1/] (metric tons-estimated live weight)

Group	Western Australia	Australia (total)
Crayfish	7,428	11,898[2/]
Perches, croakers, breams, bass, and similar species (including Australian salmon, whiting, and jewfish)	2,898	11,661
Prawns (Penaeus spp. and Metapenaeus spp., etc.)	830	5,476
Mullets, barracudas, and similar species (including sea and yellow mullets)	658	5,779
Sharks and rays	371	4,808

[1/] Excerpt from the Production Statistics for 1964-65 of Australia published in Australian Fisheries Newsletter, March 1966.

[2/] Total landings of southern, eastern, and western crayfish.

4.2.11.7 Programs for exploration, research, and development. There seems to be no special difficulty in carrying out various programs of research on the aforementioned stocks. It is suspected that the stock of western crayfish is overfished. Australian scientists estimate the optimum yield of crayfish in the west Australian stock to be 7.3 ± 0.9 thousand metric tons. Preliminary regulations of the western crayfish fishery have been initiated by limiting the numbers of fishing boats and the amount of fishing gear, and the introduction of gates in the crayfish pots to allow escapement of small crayfish. The effects of these regulations on the stock are being studied. Preliminary assessments in Shark Bay suggest that the exploitation rate on the prawn stocks is moderately high.

4.3 Inadequacy of statistics from coastal waters

Our attempts to compile information on areas with potential increase of fishery yield have shown that statistics for most countries are inadequate. Lack of division into species groups and of separation of demersal from pelagic-neritic yield, as well as obvious errors in the statistics of a few countries, will hamper attempts to obtain reliable estimates of the fishery resources. We suggest that a first step towards resource evaluation should be an improvement in the statistical recording of fishery data. Data on length frequency, size and sex, and yield per unit of effort for developed and virgin fisheries just being developed should be collected on a regular basis. The collection of these data for the developing fisheries is especially important, since reliable estimates of stock size and natural mortality can be readily obtained at that time, but are extremely difficult to get later.

4.4 Coastal areas and resources of the Indian Ocean requiring attention

From the information compiled above, it is clear that a number of areas or particular stocks show promise of increased yield. These are outlined below.

4.4.1 Bottom trawling on the coasts of Pakistan, west coast of India, Bay of Bengal, and Thailand

Work by Tiews (in press) suggests that a major resource of bottom fishes along these coasts is virtually unexploited. Experimental trawling with trawls adapted for muddy bottoms suggests a potential fishery of between one-half and one million metric tons from this area. These figures are based on shelf regions of the Gulf of Thailand, the Philippines, and the Indian Ocean coast of Thailand (Department of Fisheries, Thailand, unpublished); their extrapolation to the whole shelf area is risky so the above estimate may not be accurate. They nevertheless suggest that a survey of these areas with light trawlers, plus gear of the type proven functional in the Thailand area, is overdue. Yamamoto (in press) showed the varied distribution of trawling effort now put into this area.

4.4.2 The Gulf of Aden and adjacent waters

The productivity figures for the Gulf of Aden suggest an enormous total biomass potential for this area. Both Sardinella and associated small neritic-pelagic species (the seerfishes) and fish that can be taken by bottom trawl may be present in large numbers. A survey of the productivity (C_{14}) of the area over an annual cycle, combined with a sonar survey of the abundance and distribution of fish schools, over the full area of upwelling, could give vital information to substantiate the estimates based on productivity. The present oceanographic data taken by the Discovery, Anton Bruun, and Vityaz (Kabanova, 1961; Ryther and Menzel, 1965) show so much promise that perhaps too much reliance is being placed on them in the overall view of Indian Ocean potential fish production. The productivity estimates are as yet few in number and do not cover the whole annual cycle. In spite of the lack of close relation between productivity and fishery yield, further productivity and particularly exploration by sonar would be of great aid in obtaining some broad estimate of yield from this area.

4.4.3 Oceanic islands and banks of the western Indian Ocean

The only adequate survey in this area suggested great potential yield of bottom fishes--an estimated 2.8 million metric tons (Wheeler, 1953). Slight expansion of fishing effort is projected for Mauritius. Although the exploitation of such stocks of prime food fishes on rocky bottoms, and far from markets, may be difficult, some reassessment of the potential should be made and consideration of technical improvements in fishing methods should also be made at some stage if this is the vast untapped resource that the Mauritius-Seychelles survey indicates.

4.4.4 Prawn fisheries of the African east coast and Madagascar

In the extensive mangrove areas of Mozambique, Tanzania, Kenya, and Madagascar lies an underutilized prawn resource. Because of the ready sale for local consumption or export, a number of plans to exploit these prawns are under way (Beira Gulf in Mozambique, northwest coast of Madagascar, Rufiji delta of Tanzania). Since problems in these areas may be similar, the rate of development of the prawn fisheries may be accelerated by a rapid exchange of information on techniques of fishing, effect of fishing on stock size and other related problems.

4.4.5 Resources of prawns and bottom fishes of the northwestern coast of Australia

This area is poorly known, but work is projected by the Australian Government in conjunction with industry on prawn resources. It is likely, from recent prawn surveys and industrial ventures in the Gulf of Carpenteria, that the potential for prawn is good. Substantial catches of bottom fishes of good quality were made during a Japanese bottom trawling survey (Masuda et al., 1964).

4.4.6 Estuarine mussel culture

Mussel and fish farming in mangrove estuarine areas may be another means of increasing production. In such areas in the Gulf of Thailand mussels are produced as a by-product of the bamboo stake trap fishery, and landings of Mytilus maragdinus in 1961-63 amounted to 70-87 thousand metric tons (Tiews, in press). In the delta area of the Bay of Bengal such an industry may have great potential. These areas cover about 5,000 square miles which gives some indication of the tremendous potential in this type of fish farming (Anon., 1958).

5. LITERATURE CITED

Anonymous. 1958 Preliminary report of the marine fisheries of East Pakistan Central Fisheries Department, Government of Pakistan, Technical Report No. 1, 32 p.

El Saby, M.K. and L. Farina. 1954 Report to the Government of Saudi Arabia on possibilities for development of marine fisheries. FAO 54/12/7374. FAO Rep. No. 330.

FAO. 1967 Western and eastern Indian Ocean catch statistics, 1965 (COFI: I/1/67/INF. 1)

Ferrer, G.G. 1958 Report to the Government of Saudi Arabia on the exploration and commercial fishing operations in the Red Sea. FAO/58/5/3817. FAO Rep. No. 877.

Hayashi, S. 1966 Symposium on tuna fisheries, Part II. Stock assessment, present status of the major fishery resources, 3. Yellowfin, 4. Southern bluefin. Bull. Jap. Soc. Scient. Fish., 32: 767-777.

Hynd, J.S., G.L. Kesteven and J.P. Robins. 1966 Tuna in southern Australian waters. Food Techn. Austr., 18: 190-272.

Jones, S. In press A preliminary report on the commercial sea fisheries of the western sector of the IPFC region. IPFC/C66/TECH 33; IPFC, 12th Session, Honolulu, Hawaii, U.S.A.

Kabanova, Ju. G. 1961 Primary production and nutrient salt content in the water of the Indian Ocean. Okeanol. Issled., 4: 72-75.

Kamimura, T. 1966 Symposium on tuna fisheries, Part II. Stock assessment, history of the fishery and general review on the information obtained from past studies. Bull. Jap. Soc. Scient. Fish., 32: 756-758.

Kataoka, A. 1957 At the middle Indian Ocean about result of tuna longline fishing examination. J. Shimonoseki Coll. Fish., 6(2): 241-248.

Kawakami, T. and T. Kitahara. 1964 On the decline in the catch per unit of fishing effort and diminution of average body length due to the exploitation of a virgin stock. Bull. Jap. Soc. Scient. Fish., 30: 821-827.

Kesteven, G.L. and G.R. Williams. 1965 Australian unit fisheries. In Intersession Report (1962-1964) of Technical Committee I submitted to the 11th Session of the IPFC. Appendix B, Indo-Pacif. Fish. Coun., Occ. Pap. 65/3.

Kikawa, S. 1966 The distribution of maturing bigeye and yellowfin and an evaluation of their spawning potential in different areas in the tuna longline grounds in the Pacific. Nankai Reg. Fish. Res. Lab. Rep., 23: 131-208.

Kikawa, S. and M.G. Ferraro. In press Notes on the maturation of tunas in the Indian Ocean. IPFC/C66/TECH 24; IPFC, 12 Session, Honolulu, Hawaii, U.S.A.

Kristjonsson, H. 1956 Report to the Government of Sudan on a brief survey of the Sudanese Red Sea fisheries (July 1955). FAO/56/6/4864. FAO Rep. No. 510.

Marr, J.C. and L.M. Sprague. 1963 The use of blood groups in the study of subpopulation. Intern. Comm. Northwest Atlantic Fish., Spec. Publ., 4: 308-313.

Masuda, K., S. Nakane, S. Saito and T. Fujii. 1964 Survey of trawl grounds off the northwest coast of Australia with special reference to hydrographic conditions of the ground. Bull. Fac. Fish. Hokkaido, 15(2): 77-88.

Mimura, K. 1958 Study of the fishing conditions of the yellowfin in the Indian Ocean, especially on the differences of the hooked-rate and size composition. Nankai Reg. Fish. Lab. Rep., 7: 59-71.

Mimura, K. and Y. Warashina. 1962 Studies on Indomaguro (Thunnus maccoyii). Nankai Reg. Fish. Res. Lab. Rep., 16: 135-154.

Nakamura, H., Y. Yabuta and K. Mimura. 1958 Longline fishing ground for tunas in the Indian Ocean. (6th Meeting, IPFC, 1955), Sec. 2-3: 220-238.

Oswald, E. 1958 Report to the Government of Sudan of the Red Sea fisheries. FAO/58/8/6066. FAO Rep. No. 934.

Panikkar, N.K. 1966 Fishery resources of the Indian Ocean. Paper submitted to the Working Party on the Rational Utilization of the Fishery Resources of the Indian Ocean, FAO, Rome, Italy, 23-25 January 1967, 38 p.

Robins, J.P. 1963 Synopsis of biological data on southern bluefin tuna Thunnus thynnus maccoyii (Castelnau) 1872. World Sci. Mtg. Biol. Tunas and Rel. Sp., 1962, La Jolla, Calif. FAO Fish. Rep., (6), Vol. 2: 562-587.

Ryther, J.H. and D.W. Menzel. 1965 On the production, composition, and distribution of organic matter in the western Arabian Sea. Deep-Sea Res., 12: 199-209.

Sakamoto, H. 1966 Annual changes in the abundance and age composition of bigeye tuna in the Indian Ocean for the years 1955 through 1963. Nankai Reg. Fish. Res. Lab. Rep., 24: 31-40.

Suda, A. 1966 Symposium on tuna fisheries, Part II. Stock assessment, present status of the major fishery resources, 1. Bigeye, 2. Albacore. Bull. Jap. Soc. Scient. Fish., 32: 758-767.

Suzuki, A., T. Morio and K. Mimoto. 1959. Blood group frequencies of the albacore in Tg-system. Part 1. Comparison of the Indian and northwestern Pacific Ocean. Nankai Reg. Fish. Res. Lab. Rep., 11: 17-23.

Sverdrup, H., M. Johnson and R. Fleming. 1946 The oceans - their physics, chemistry, and general biology. Prentice-Hall, Inc., 1087 p.

Talbot, F.H. and M.J. Penrith. 1963 Synopsis of biological data on species of the genus Thunnus (sensu lato) (South Africa). World Sci. Mtg. Biol. Tunas and Rel. Sp., 1962, La Jolla, Calif., FAO Fish. Rep., (6), Vol. 2: 608-646.

Tiews, K. In press On the possibilities for further developments of the south-east Asian fisheries until the year 2000. IPFC/C66/TECH 2; IPFC, 12th Session, Honolulu, Hawaii, U.S.A.

Tongyai, M.L. Prachaksilp. In press Unit fisheries of Thailand (marine). IPFC/C66/WP 15; IPFC, 12th Session, Honolulu, Hawaii, U.S.A.

Wheeler, J.F.G. 1953 Report on the Mauritius-Seychelles fishery survey 1948-1949, Part IV. General considerations and conclusions. Fish. Publ., Lond., 1(3): 120-143.

Yamamoto, T. In press Approximate inventory of trawlers in the Indo-Pacific area. IPFC/C66/WP 17; IPFC, 12th Session, Honolulu, Hawaii, U.S.A.

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